THE WHY, WHAT, AND HOW OF THE STRATEGIC DEFENSE INITIATIVE

By Brigadier General Robert R. Rankine, Jr., USAF

General Rankine holds three separate jobs within the Air Force, all of them related to the Strategic Defense Initiative (SDI). He is special assistant for SDI to the Deputy Chief of Staff, Research, Development and Acquisition; special assistant, SDI, to the Vice Commander, Air Force Systems Command; and he is responsible, at USAF headquarters, for the Air Force's science and technology program. In recent assignments prior to taking up his present duties, he served in the Office of the Under Secretary of Defense for Research and Engineering as assistant for directed energy weapons and SDI planner, and as Deputy Director of the Strategic Defense Initiative Organization. This article is based on a speech to the American Institute of Aeronautics and Astronautics.

In his March 1983 defense policy speech, President Reagan discussed his continued support for strategic offensive modernization and arms control efforts. He also challenged the scientific community to determine the feasibility of developing systems capable of destroying ballistic missiles in flight, thus providing an alternative to sole reliance on offensive nuclear retaliation as the basis for strategic deterrence, and leading to the ultimate goal of eliminating the threat of ballistic missiles.

Immediately following that speech, the President directed that two studies be accomplished to investigate the policy and the technology implications of an effective ballistic missile defense system. From these two studies emerged the basis for a long-range research program. In October 1984, the Congress appropriated funds for the Strategic Defense Initiative, financing the new hope for the future, first expressed by the President less than nineteen months earlier.

To best understand the scope and breadth of this initiative, I will answer three questions:

First, **why?**—which will address the strategy and policy implications of an effective ballistic missile defense.

Second, **what?**—which will describe the scope and priorities of the research program underway to determine technical feasibility.

And lastly, **how?**—which will describe the procedures we have established to centrally plan and control the program, yet decentrally execute the technology efforts.

In the long term, we have confidence that SDI will be a crucial means by which both the U.S. and the Soviet Union can safely agree to very deep reductions and eventually even the elimination of ballistic missiles and the nuclear weapons they carry. This does not represent a shift from the basic deterrent strategy of the U.S., but represents a new means for enhancing deterrence. That policy, in effect since the beginning of the nuclear era, has not changed in its fundamentals, but our ability to deter has hinged upon differing military capabilities, ranging from a balanced nuclear bomber and air defense capability in the fifties to almost total reliance on the threat of retaliation in the eighties. The shifts in the basis for deterrence have been forced by the development of various nuclear delivery systems and not by fundamental changes in policy.

The emergence of nuclear tipped ballistic missiles in the late fifties and sixties changed the timing of nuclear warfare and thus reduced the importance—in the view of many U.S. leaders—of the need for air defenses. Because ballistic missiles are fast and unrecallable and are becoming increasingly accurate, they potentially are the most destabilizing of the currently deployed systems—particularly the ICBMs which may be tar-

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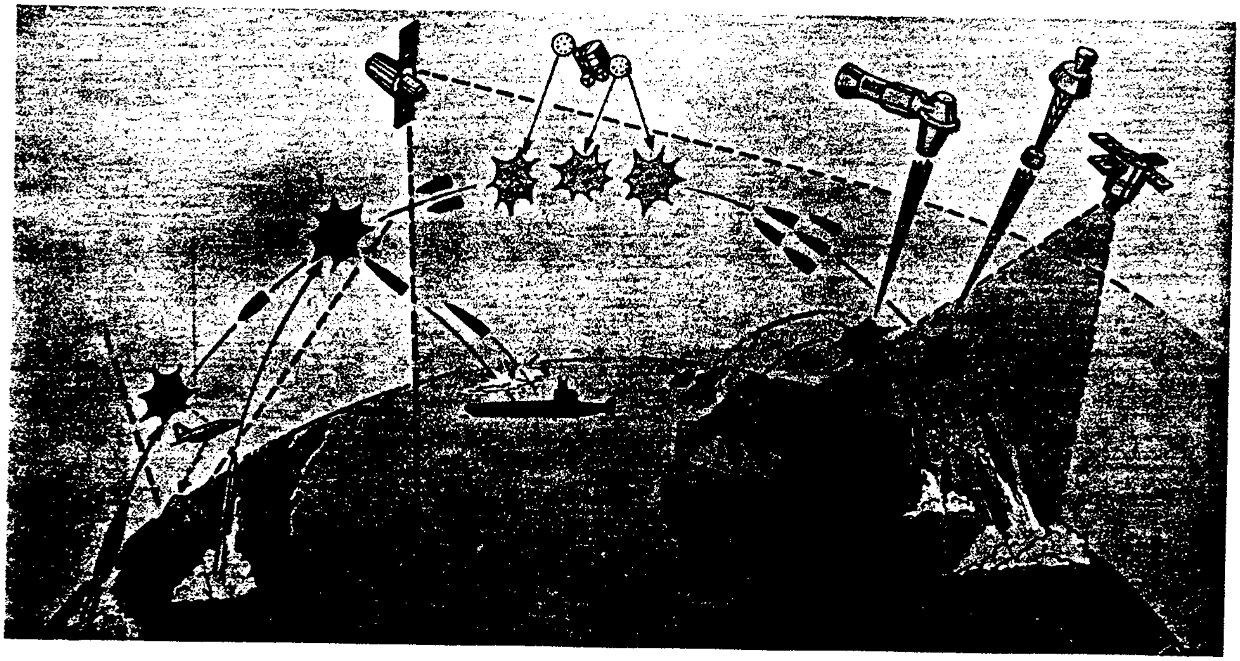
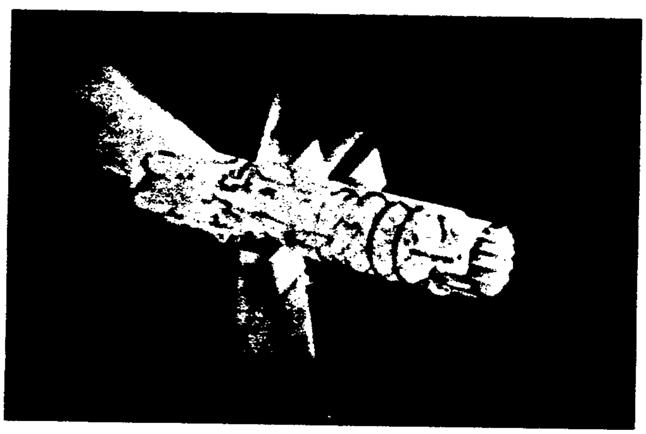
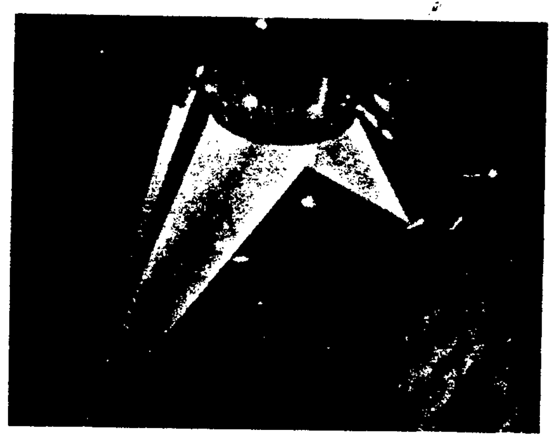


This overview of the Strategic Defense Initiative research plan illustrates the four-layered defense system contemplated: attacking ballistic missiles in their boost and post-boost phases, during midcourse flight and in the terminal portion of their trajectories as they descend into the atmosphere.

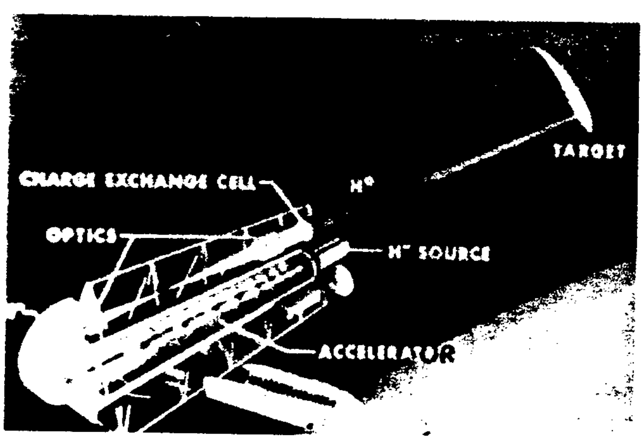
Laser and particle beam systems are among the major candidates for directed energy weapon (DEW) systems, which attack ballistic missiles at or near the speed of light. Lasers are designed to kill by burning a hole in the target vehicle; particle beams penetrate the target's interior to destroy electronic and other internal components.



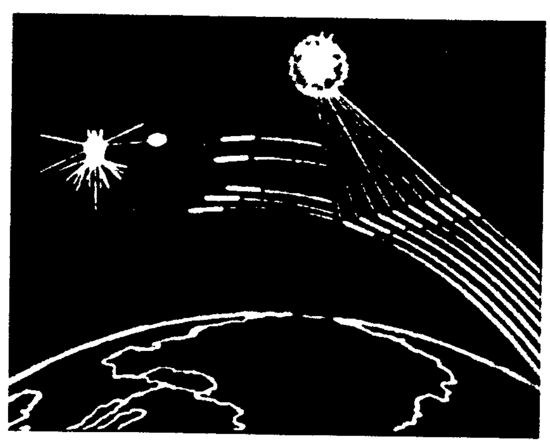
SPACE BASED LASER



GROUND BASED LASER



NEUTRAL PARTICLE BEAM



X-RAY LASER

An example of a directed energy weapon is the space-based laser system, which offers the opportunity to intercept ballistic missiles in the boost phase, before they can deploy their warheads and decoys. Since laser light penetrates the atmosphere, this type of system may also have potential in defense against airbreathing missiles or aircraft.

geted against each other. Therefore, a ballistic missile defense capability has the potential of increasing deterrence and adding to stability, by increasing substantially the uncertainties in the success of nuclear attack by an enemy, thoroughly confounding his targeting strategy, thus significantly reducing or eliminating the utility of preemptive attack. The system need not be perfect to accomplish this objective, but must meet three important criteria:

- First, it must be effective against the systems and countermeasures that exist or could be deployed.
- Second, it must be sufficiently survivable that it would not encourage an attack on the system itself by either enemy defensive or offensive systems. If it were not survivable, then it might invite a defense suppression attack as a prelude to an offensive attack, thereby decreasing rather than increasing crisis stability.
- Third, in addition to being effective and survivable, defenses must be able to be expanded to maintain effectiveness at lower cost than any proliferation or countermeasure attempts to overcome them. If that were not the case, the existence of defenses would encourage rather than discourage proliferation. Providing for cost-effective and survivable defense is the key challenge to the Strategic Defense Initiative technology program and illustrates the need for research before an informed decision to begin system development is possible.

In the late sixties and early seventies, the United States had done developmental work on an anti-ballistic missile system known as Safeguard. That system, which was deployed in the mid-1970s, was dismantled shortly thereafter, due in part to the fact that it could not maintain effectiveness against proliferation. The U.S. also hoped that not deploying U.S. defenses permitted by the ABM treaty would encourage the Soviet Union not to build more ballistic missiles. It did not. Not only did the Soviets continue to build ballistic missiles, they also relentlessly pursued technology for defending against ballistic missiles.

An example of this was shown in the U.S. Department of Defense publication *Soviet Military Power 1984*, which described a directed energy R&D site at Sary Shagan in the central Soviet Union that not only could provide an antisatellite capability today, but possibly a prototype for an ABM system to be deployed in the future. The Soviets have currently the only operational ballistic missile defense, which is located around Moscow. The system is for terminal defense and similar in many ways to the Safeguard system that we had deployed in the early 1970s. The Soviets are presently modernizing that Moscow system and have developed a rapidly deployable ABM system which has potential for deployment as a nationwide ABM system.

Of even greater concern however, the Soviets have been pursuing for many years extensive development of technologies which have potential for advanced ballistic missile defense applications. Whereas the United States has been developing basic laser technology, the Soviet Union is exploring many laser technologies. In the particle beam area, the most advanced U.S. technology is derived from Soviet research reported in their technical literature several years ago.

The Strategic Defense Initiative program thus provides us a hedge against what might otherwise be a Soviet technical surprise. A unilateral Soviet deployment of such advanced defenses, in conjunction with its offensive deployments and its air and civil defense efforts, could result in a significant change in Soviet military capability and could adversely affect the security of the United States and its allies.

Some of the opponents of the Strategic Defense Initiative have argued that the research and technology program currently under way is inconsistent with the ABM treaty and conflicts with arms control in general. Quite to the contrary, the initiative is totally consistent with current U.S. ABM treaty obligations. The initiative contemplates only research and experimentation on a broad range of defensive technologies to provide the basis for a decision in the future whether or not to develop systems which would provide an effective ballistic missile defense capability.

As we look toward the future, effec-

tive defenses have the potential of decreasing the value of ballistic missiles as instruments of national strategy, thus increasing the likelihood of negotiating reductions in those ballistic missiles. Negotiated reductions in offensive forces, in turn, will enhance the effectiveness of the defenses; we have created a defensive spiral in which both parties would be more willing to negotiate further reductions. Thus defenses couple synergistically with arms control leading to attainment of the ultimate goal stated by the President: to eliminate all threats posed by nuclear ballistic missiles.

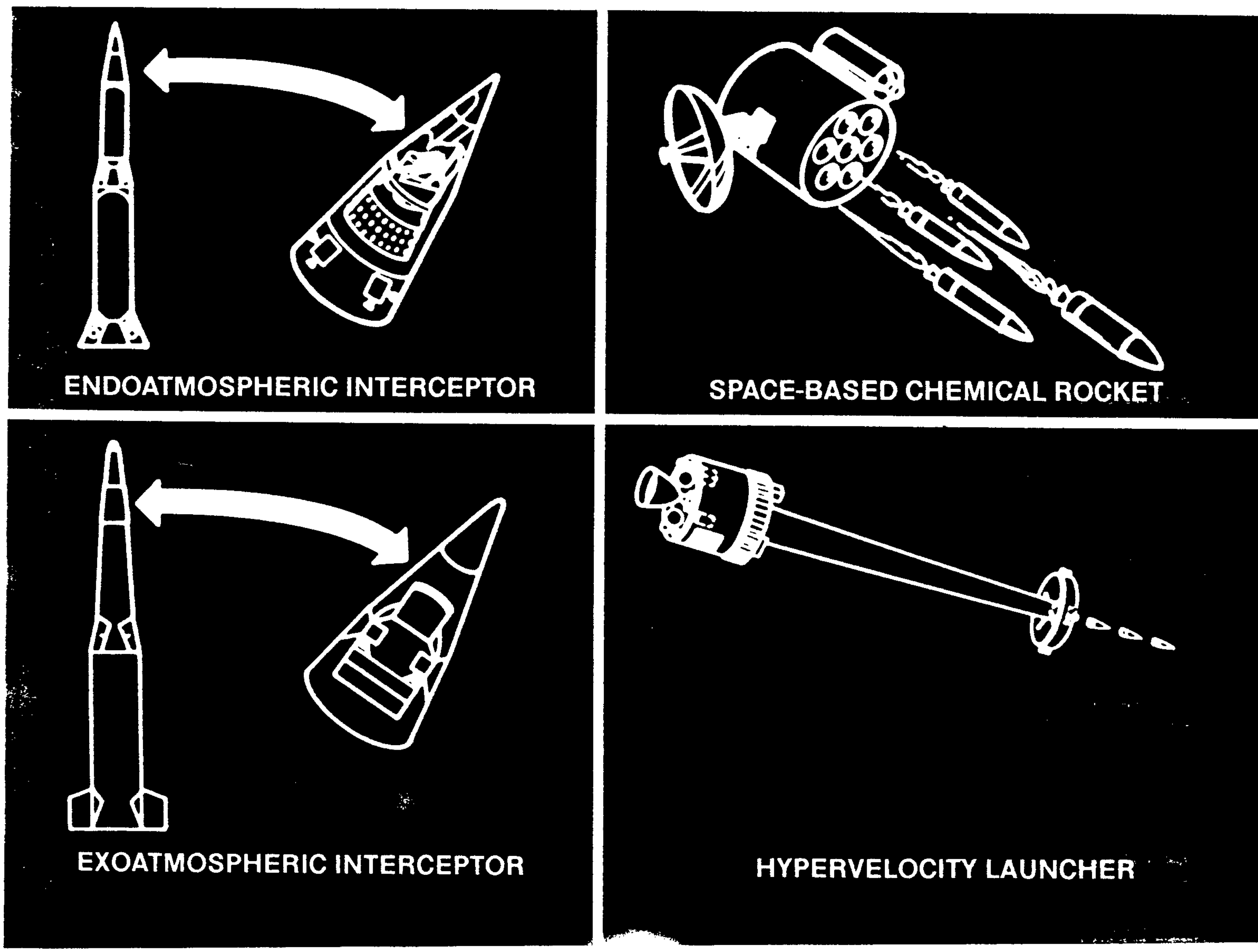
An important aspect of the entire initiative is the fact that the United States is in no way decreasing its commitment to the protection of its allies but, in fact, is examining technologies for defense not only against ballistic missiles that can hit the United States, but against shorter range ballistic missiles that can strike our allies. We are consulting closely with our allies.

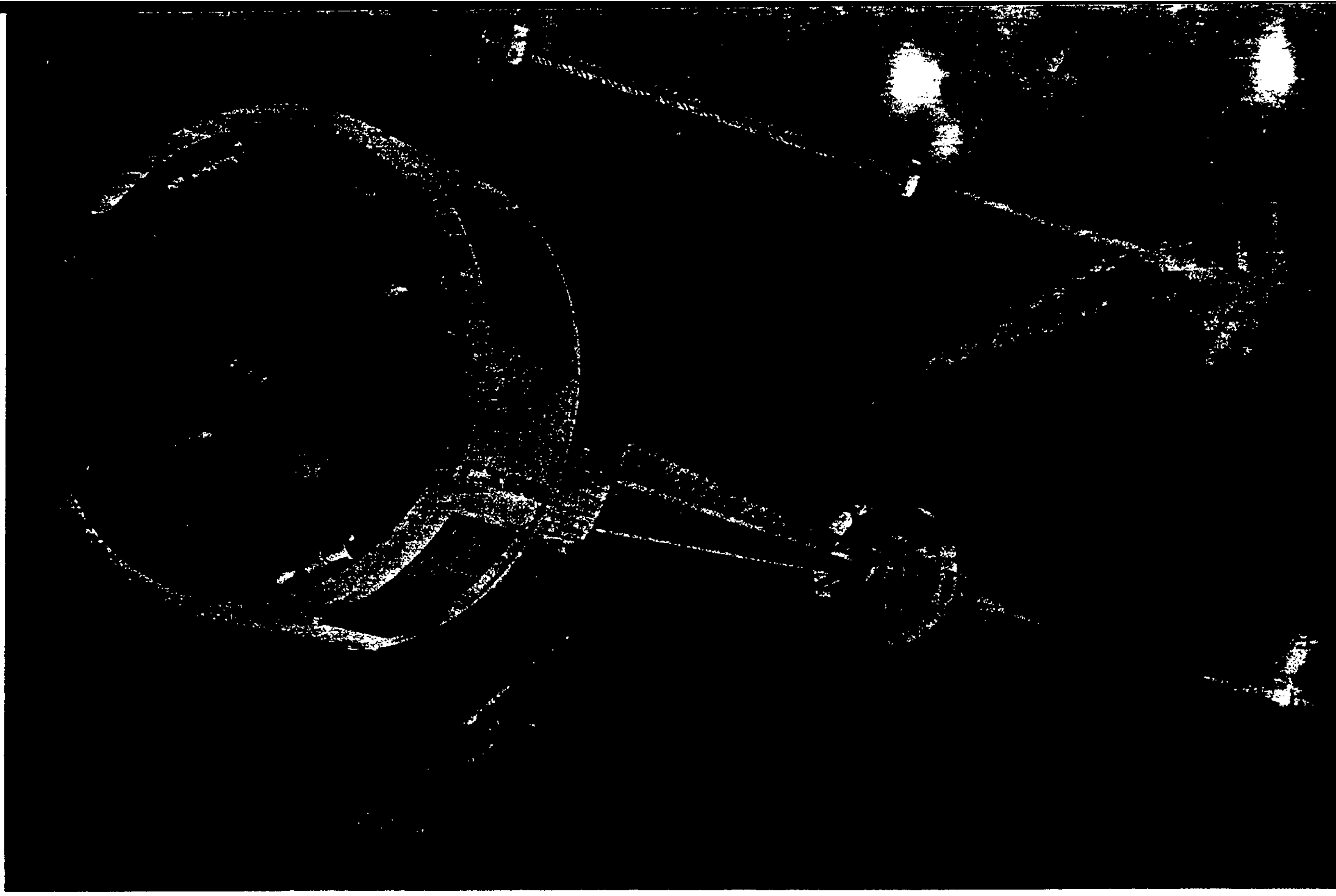
The emphasis in the Strategic Defense Initiative on defending against ballistic missiles is due to their potential to increase instabilities. But while the slower moving systems, such as cruise missiles and bombers, are less threatening in this regard, there are separate efforts under way in the services to examine the technologies required to defend against these weapon systems as well.

Having described the rationale for the program, I will now describe its technical scope and what has changed over the last 10 years that has made defense against ballistic missiles both more realizable and more effective. To do this, it is important to understand the flight path of a ballistic missile and the various regimes in which ballistic missiles can be attacked. It starts in the boost phase, in which the ballistic missile, being thrust by a large chemical rocket, slowly rises from the face of the Earth enroute to its targets. This phase can be characterized by an intensely bright plume which provides a very large characteristic infrared signature. In this phase, the ballistic missile still has all its warheads attached. Attack in this phase could provide large multiplier effects and would thus provide maximum leverage from a defensive point of view.

In the next phase, post-boost or the bus deployment phase, warheads and penetration aids are deployed in such a way as to attempt to confuse the defenses. This phase is followed by the longest phase, the mid-course phase. The warheads and penetration aids coast on a ballistic trajectory from minutes to tens of minutes on the way to their target. In the last phase—the terminal phase—the warheads and the decoys re-enter the atmosphere. Discrimination

The SDI program involves research on four kinds of kinetic energy weapons, or "smart bullets," each equipped with a small computer and a lightweight sensor: the endoatmospheric interceptor, intended to hit an incoming missile in the terminal phase of its trajectory; the exoatmospheric interceptor, designed for intercept outside the atmosphere in the missile's midcourse phase; small chemical rockets, emplaced on space-based "pods," for intercept in the boost and midcourse phases; and the hypervelocity weapon, also intended for boost/midcourse intercept.





Among kinetic energy weapon systems being investigated is the space-based hypervelocity launcher, or rail gun, which employs electrical forces rather than chemical propellants to fire "smart" projectiles. The electric gun may be able to generate projectile velocities of more than 20 miles a second, compared with five miles a second for chemical rockets.

is facilitated in this phase by the differing re-entry dynamics and signatures of the warheads and decoys.

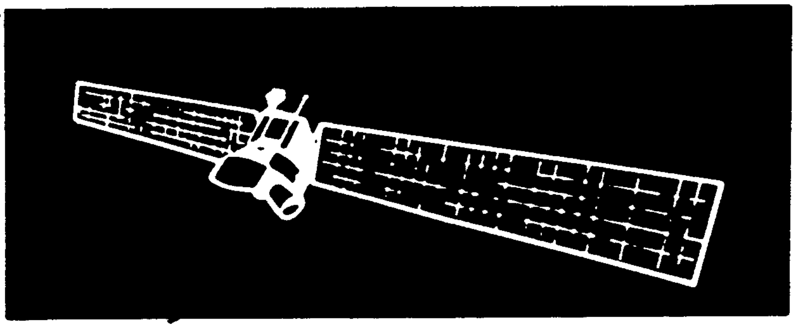
Attacking ballistic missiles in all four of these phases is what is known as a layered defense system. This is a defense-in-depth approach that is not new to the military. For example, it is similar in concept to the approach used by the U.S. Navy to protect a carrier task force. We have the F-14 Tomcat attacking aggressors at long range using the Phoenix missile system; at shorter ranges, using Sparrow and Sidewinder missiles; then followed up by surface-to-air missiles from the support vessels and finally by the Phalanx gun system. Layered defenses relieve the effectiveness requirements on each individual layer and are more resistant to countermeasures.

Certain functions need to be accomplished in each of these four phases for ballistic missiles to be effectively attacked; first, detection, acquisition, discrimination and kill assessment; second, pointing and tracking; third, interception and destruction, and fourth, battle management. The scope of the Strategic Defense Initiative program can be discerned by identifying weapon system concepts for each function in each phase. The collection of technologies that will permit the realization of these concepts defines the technical scope of the program. As an example—in the boost phase—the requirements for detection, acquisition, discrimination and kill assessment could be accomplished by taking advantage of the very bright signature of the booster itself. Space-based infrared sensors could detect and track the booster and thus handoff to a boost phase interception and destruction capability which would employ either directed energy or kinetic energy. The technologies which support such a concept include focal plane arrays, light-weight optics and signal processing for space applications; programs in each of these technical areas are now being pursued under the central management of the Strategic Defense Initiative program. All of these key technologies were being pursued previously; hence, the Strategic Defense Initiative is not a new program, but an entirely new focus for a collection of relevant programs.

For better appreciation of the scope of the program, let me describe some notional architectures for the sensors and weapons that might fulfill the functional requirements of a multi-layered defense.

In the sensor area, we are looking at five interleaved system concepts—first, a boost-phase detection and tracking system which would detect launches of ballistic missiles. In the mid-course area, we perceive the need for a "birth-to-death" tracking and fire control system to provide the tracking of the reentry vehicles from deployment to reentry. Also in the mid-course, we see the need for a laser or radar system to image the post-boost vehicle to observe reentry vehicle and decoy deployment and thus discriminate between the two. In the terminal phase, two systems are currently envisioned, one an airborne optical adjunct which would provide for long-range infrared tracking and discrimination of the reentry vehicles and decoys. And lastly, a ground-based imaging radar which would provide endoatmospheric discrimination of reentry vehicles and decoys.

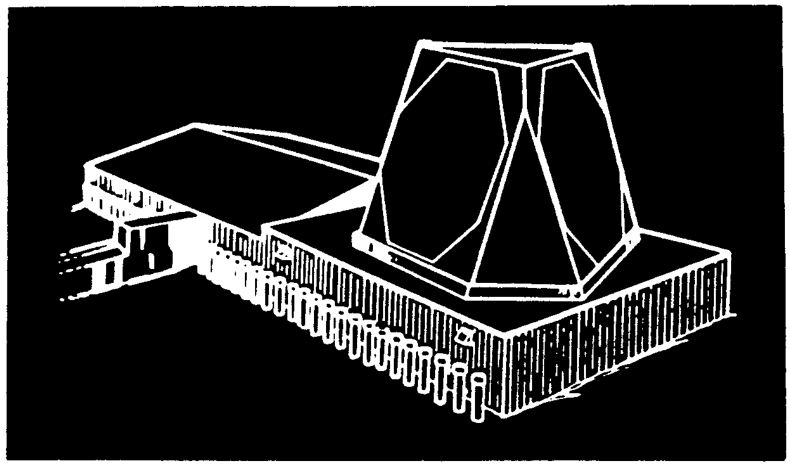
In the kinetic energy weapons area, both ground-based and space-based assets would provide for attack of ballistic missiles in all phases. In the boost-phase, space-based projectiles propelled by chemical rockets or electromagnetic launcher systems would provide a capability of attacking the booster while it is still under power. These same systems would also be capable of attacking post-



SPACE SURVEILLANCE

The SDI Sensors Program is organized into two parts: technology development for new sensors, imaging techniques and associated data processors that will aid in discriminating decoys from warheads; and experimental demonstrations to validate new technologies and provide confidence that full scale development can be initiated.

AIRBORNE OPTICAL SENSOR



TERMINAL RADAR

boost vehicles and reentry vehicles during midcourse flight. In the terminal and late mid-course area, ground-based interceptors would provide a non-nuclear hit-to-kill capability to destroy the reentry vehicles on a one-to-one basis.

Last June, the homing overlay experiment (HOE) conclusively demonstrated the technology of hit-to-kill intercept of reentry vehicles. Some new technology breakthroughs have recently occurred in the hypervelocity launcher area. We have been able to accelerate projectiles from a repetitively fired electromagnetic railgun launcher up to several kilometers per second. In addition, preprogrammed maneuvering projectiles have functioned after sustaining accelerations in excess of 50,000 Gs.

Directed energy weapons are being investigated primarily to attack ballistic missiles in either the boost or post-boost phase. Several options currently exist. Chemically powered space-based lasers might provide long range, speed-of-light intercept and kill of both boosters and post-boost vehicles. Alternatively, ground-based excimer or free electron lasers could bounce their energy off space-based mirrors and thus be able to attack a large number of boosters without the need to put the laser device in space. Neutral particle beams can penetrate deeply into the ballistic missiles, causing catastrophic damage to internal components. Recent work on the Navy's Mid-Infrared Advanced Chemical Laser (MIRACL) has demonstrated not only the highest power, but now also the highest brightness of any laser in the free world. This laser, at the White Sands Missile Range, will be a work horse for the Strategic Defense Initiative, allowing us to determine by actual testing the trade-offs between booster hardening and laser brightness.

Not everything within the broad technical scope of the Strategic Defense Initiative is equal in priority. Five priority technology areas can be defined which provide the keys to an effective defense. First is the definition of weapon concepts for boost-phase and post-boost vehicle intercept. Directed energy weapons such as lasers and particle beams have the promise to provide for long-range intercept of the booster and the post-boost vehicle at or near the speed of light. Kinetic energy projectiles propelled to hypervelocity by chemical propellants or electro-magnetic force also offer potential for such early intercepts. Concurrent with the pursuit of technologies that will make such weapons possible is the definition of the lethality required, not only against currently deployed Soviet ballistic missiles, but also against new missiles built to incorporate countermeasures intended to overcome the effectiveness of these new weapons.

In the mid-course area described earlier, the key to cost-effective defense is discrimination of reentry vehicles from the decoys. If discrimination can be accomplished with sufficiently high confidence, mid-course intercept can be obtained with reasonable numbers of interceptors. By simultaneously advancing technology to reduce the cost of the mid-course interceptors, one can trade off the effectiveness of the discrimination with the cost of attacking more expensive decoys in addition to true reentry vehicles.

Survivability of space-base defense assets is a key to the program. Since these systems must be sufficiently survivable to preclude a pre-emptive attack upon them, major emphasis in the Strategic Defense Initiative program will be to develop survivability measures for the space-based assets to include such things as electronic countermeasures, self-defense, decoys and hardening. However, we are not only looking at the technology to enhance the survivability

of single satellites, but are also exploring the full range of tactics to provide for overall mission accomplishment without the dependency on any one satellite. Tactics of this kind include such things as escort defense, orbit selection, proliferation and maneuver.

The last, and not the least, most important priority technology is in the area of battle management. In the past, the development of high-speed computational capability for the real-time battle management of such a system would have precluded the development and deployment of such an effective layered defense. Today's computer processing capabilities, which are growing by an order of magnitude every three to four years, promise to provide the technology sufficient to support such a system by the turn of the century. Of greater concern, though, is the issue of software preparation and testing. We currently do not have the capability to build and validate the software necessary in a timely manner. Hence, research on "software development tools"—that is, computer programs that can write and test new computer programs—are receiving high priority attention.

With the scope and the priorities of the Strategic Defense Initiative research program thus defined, let me turn now to the question of how the program is being executed. The Congress appropriated $1.6 billion for the Strategic Defense Initiative for Fiscal Year 1985—$1.4 billion for the Department of Defense and $200 million for the Department of Energy. Although this was only 80 percent of what the President had requested, it has nevertheless permitted a focused, centrally-managed beginning for the Strategic Defense Initiative. We believe that the central management of those funds by General Abrahamson's Strategic Defense Initiative Organization (SDIO) has introduced economies and efficiencies which enable us to get more for that money than if the pieces were pursued separately.

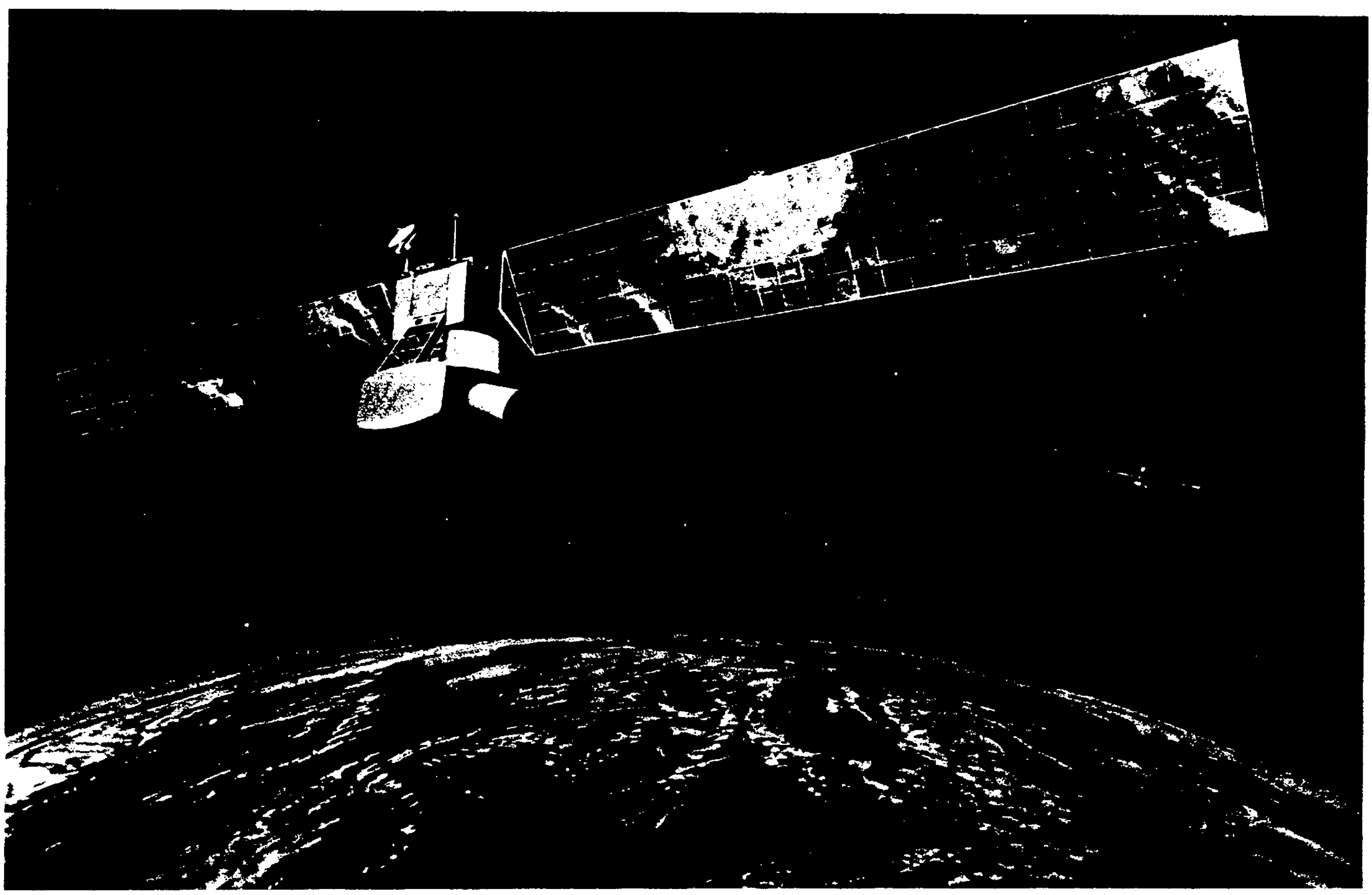
The overall management of the program is characterized by centralized planning and control by the Strategic Defense Initiative Organization with decentalized execution by the Army, Air Force, Navy, DARPA, Defense Nuclear Agency and the Department of Energy.

In FY 85, the two largest executors are the Army and Air Force, with 40 and 35 percent respectively, of the DoD portion of the program. The Army and the Air Force were able to undertake such large portions of work in Fiscal Year 1985 because the work had actually begun in previous years. That is, the Strategic Defense Initiative provided a new context and focus for the Army's prior work on ballisitic missile terminal defense and the Air Force's prior work on space surveillance and space defense. For example, the Air Force was developing technology for detecting and tracking satellites using long-wavelength infrared space-based sensors. This basic technology, with improvements in sensitivity and resolution, provides the basis for reentry vehicle tracking.

Based upon the $3.7 billion budget request for the DoD part of the program submitted to Congress, the distribution of the funds in Fiscal Year 1986 will remain much the same as in 1985.

For the ease of presentation and man-

Experiments envisioned include demonstrations of space-based sensors emplaced at high altitude (illustration) for boost phase surveillance and tracking, and a midcourse surveillance system that will enable detection, tracking and discrimination of all objects in low Earth orbit, including ballistic missile warheads, decoys and debris.



Among supporting technologies being investigated in the SDI program is a space-based system for generating high power levels. The artist's concept shows the ST-100 Space Nuclear Reactor Power System being developed under Department of Defense/Department of Energy/NASA sponsorship.

agement, the program has been broken up into five major program elements or thrusts. The first major thrust is surveillance, acquisition, tracking and kill assessment (SATKA), which encompasses the five previously-mentioned system concepts: boost-phase infrared surveillance system, midcourse infrared surveillance, midcourse laser or radar imaging system, late midcourse to terminal airborne infrared tracking system, and a terminal imaging radar. In addition to the pursuit of technologies leading to major experiments conducted in support of each of these concepts, significant effort is underway also to gather radar and optical data on missiles and backgrounds and to investigate common technologies such as signal processing and the development of imaging algorithms. The Army and Air Force will each execute about 40 percent of the funds for surveillance, acquisition, tracking, and kill assessment in FY 86.

The second major thrust is directed energy weapons, with primary emphasis within the DoD upon space-based chemical lasers, ground-based excimer and free electron lasers, and space-based neutral particle beams. The Air Force is by far the largest executor of the directed energy work in FY 86.

The third major thrust is in the kinetic energy weapons area, which includes the concepts for space-based kinetic kill vehicles, space-based hypervelocity launchers, and ground-based endo- and exoatmospheric hit-to-kill interceptors previously discussed. All of the concepts are supported by major technology efforts in terminal homing, chemical and electromagnetic propulsion, fire control and acquisition and tracking. The Army will execute the largest portion of the kinetic energy weapons thrust in FY 86.

The fourth major thrust is systems analysis and battle management, where the main efforts are system and battle management architectures and the associated communications, command and control technologies. This area has received much attention lately with the award of 10 one-million-dollar contracts for alternate architecture studies which will identify the key trade-offs of various total-system designs. The results of these studies will help General Abrahamson guide the individual technology programs toward the achievement of overall, integrated system objectives. The funds here are divided almost equally among the Army, the Air Force and the SDIO, with the services' primary thrust in technologies and the SDIO's in systems analysis.

The fifth major thrust includes an assortment of high priority technologies which individually do not take a sufficiently large fraction of the program's funding to warrant a separate program element for each. This includes major efforts in space system survivability technology, lethality and target hardening testing, space prime power from tens of kilowatts to megawatts, and space logistics with particular emphasis on launch, orbit transfer and on-orbit support. The Air Force is conducting most of the survivability, space power and space logistics work with the Defense Nuclear Agency directing the lethality and target hardening tests with assistance by the Air Force, Army, and DoE.

A considerable amount of growth in each of these five major thrust areas has been requested in the President's budget for Fiscal Year 1986. This growth is attributable to the fact that the many technologies which make up the Strategic Defense Initiative had each reached a point where they were ripe for exploitation. It is common for the funding of an emerging technology to grow rapidly as it is experimentally applied to potential weapon system concepts after an extended period of low-level research.

The goal for the Strategic Defense Initiative was eloquently established by President Reagan in March 1983, when he challenged all of us in the scientific community to create a means for rendering ballistic missiles impotent and absolete.

The goal of the Strategic Defense Initiative has not changed at all since the President's March 1983 speech, even though the understanding of that goal by the program's opponents may have changed. The President's original goal still drives this research and technology program, with the need for the United States "to get started now", as he stated in his State of the Union address.

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On the cover: The artist's concept shows an Earth-generated laser beam being reflected toward a high-altitude target by a space-based mirror. This is one of a number of ballistic missile defense concepts being explored in the Strategic Defense Initiative research program *(see page 2).*

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A Perspective on the Defense Industry

BY KARL G. HARR, JR.
President, Aerospace Industries Association

The following is a reprint of an article by Dr. Harr in "The Debate" section of USA Today *in April:*

Defense and space business is paid for by the taxpayer, involves vital national security interests, and is controlled by the government customer. Thus, defense is the "people's business" and both the media and the political establishment justly feel they have a right and a duty to monitor it closely.

It is important to place in perspective the essential characteristics of the defense industry and the procurement process under which it operates.

The defense industry is large, with annual sales well over $100 billion. It is enormously complicated, charged not only with producing but *inventing* complex systems at the cutting edge of technology. Its high-tech products must meet extraordinary standards of performance and reliability.

It is free enterprise that must serve two masters, the government customer and the corporate stockholders. It is perhaps the most closely audited and scrutinized industry in the history of our nation.

But, as a peacetime entity, it is a young industry, born in the wake of World War II to counter a Soviet threat and publicly supported, in the years since, only as long as and to the extent that such a threat was perceived.

There were no precedents to guide the creation of a large peacetime defense establishment, so development of the procurement process has been largely a matter of experimentation, trial and error, lesson-learning in a constantly changing defense environment.

The government and industry have spent 30 years working out the necessarily complicated rules of the game. That they have substantially done so is evidenced by the exceptional performance of the industry.

It has produced—and continues to produce—the world's finest weapon systems. It has made tremendous advances in weapons capabilities, reliability, and performance as well as in deliveries within cost and schedule.

In addition, industry-developed equipment has enabled the USA to lead the world in space exploration and exploitation and to dominate world-wide sales of airline transports. Much government/industry effort has gone into the system that made these considerable achievements possible.

Admittedly, the system has on occasion come up short: a product is delivered late, costs too much, or fails to meet performance standards.

Industry can take its share of the blame. So can the Pentagon. So can the Congress. Such irregularities must be and are being corrected.

But widely publicized abuses are anomalies, not the norm. They must not be allowed to distract our attention from the main task of ensuring the efficient functioning of a process so vital to the nation's security and economy.